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Memoirs of the Department of Agriculture in India

STUDIES IN INDIAN OIL SEEDS No. 2. LINSEED

BY

GABRIELLE L. C. HOWARD, M.A

Second Imperial Economic Botanist

AND

ABDUR RAHMAN KHAN

Second Assistant to the Imperial Economic Botanist

AGRICULTURAL RESEARCH INSTITUTE, PUSA

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STUDIES IN INDIAN OIL SEEDS No. 2. LINSEED.

BY

GABRIELLE L. C. HOWARD, M.A.,

Second Imperial Economic Botanist,

PLATES I AND III.

On account of carelessness on the part of the Calcutta Phototype Company in printing the final copies, Plate I (two-colour portion) is defective but gives an idea of the point illustrated.

Plate III has suffered so much in the final printing that it is useless for showing the range and distribution of colour in the stamens and styles.

IN India, linseed (*Linum usitatissimum* L.) is grown entirely for the oil in its seeds which form an important item in the export trade. After the Argentine, this country takes the second place in providing the world's supply of linseed oil. The chief centres of production are Bihar and Orissa (165,000 tons), the United Provinces (162,000 tons), Central Provinces and Berar (67,000 tons), Bengal (16,000 tons), Bombay (10,000 tons) and Hyderabad (8,000 tons).[1] The total average production of the last five years (1918 to 1922) was 374,600 tons. The seeds are exported chiefly from Calcutta and Bombay. The most important factor in the distribution of linseed in India appears to be the soil type. The crop flourishes best on deep, moisture retaining soils in tracts where the temperature of the cold season is favourable.

Although none of the indigenous forms of linseed are cultivated for the flax in the stem, nevertheless the possibility of combining the production of linseed with the supply of flax and also of the establishment of a fibre industry

[1] *Estimates of Area and Yield of Principal Crops in India*, 1921-22. Calcutta, 1923.

have been the subject of numerous experiments in India for the last hundred and fifty years. The results of the earlier experiments are summed up in the *Dictionary of Economic Products of India* (V, pp. 10-35) while accounts of the recent trials at Dooriah and Cawnpore are published in Bulletins 25, 30 and 35 of the Agricultural Research Institute, Pusa and in the *Agricultural Journal of India*.[1,2] In these flax trials, seed imported from Europe was employed and in many cases a satisfactory fibre was obtained. So far, however, no industry has resulted, largely on account of (1) the probable necessity of storing the produce during the rains till the temperature falls sufficiently for retting to take place and (2) of importing fresh seed for sowing at frequent intervals. These difficulties place flax cultivation beyond the means of the ordinary cultivator and can only be overcome by capitalists who are prepared to purchase the crop from the growers at harvest time in April and to store it till the following autumn, at the same time supplying the cultivators with suitable seed for sowing every October. Whether such an arrangement would work in practice and whether it would be found to be remunerative to all concerned cannot be stated with certainty.

In order to obtain the types of linseed grown in India, samples of the various grades of commercial linseed were supplied to us by Messrs. Ralli Brothers from their more important buying centres. In addition, a few parcels were obtained from the neighbourhood of Pusa and also from some of the Government farms in India. The samples obtained were as follows :—

TABLE I.

Trade samples of Indian linseed.

Name of centre	Description	By whom supplied
Sitamarhi ..	Small brown	Messrs. Ralli Brothers, Calcutta. These are the most important linseed centres for the Calcutta trade and are given in order of merit as regards linseed production.
Darbhanga ..	Do.	
Bettiah ..	Do.	
Patna ..	Two samples—small brown and bold brown..	
Arrah ..	Do. do. do ..	
Chauri Chaura ..	Small brown	
Khagaria ..	Do.	
Sasaram ..	Two samples—small brown and bold brown..	
Bhagalpur ..	Small brown	

[1] Coventry, B., Flax Experiments in India, *Agri. Jour. of India*, I, 1906, p. 192.

[2] Burt, B.C., Flax in the United Provinces, *Agri. Jour. of India*, XV, 1920, p. 616.

TABLE I.—(*continued*).

Name of centre	Description	By whom supplied
Indore ..	Three samples—yellow, bold yellow and brown and bold brown	Messrs. Ralli Brothers, Bombay. These are the most important linseed centres for the Bombay trade.
Saugor ..	Bold brown	
Damoh ..	Do.	
Cawnpore ..	Three samples—bold brown, medium brown and small brown	
Sutna ..	Medium brown	
Katni ..	Do.	
Nagpur ..	Three samples—bold yellow and brown, bold brown and medium brown	
Ahmednagar ..	Bold brown	
Jalna ..	Do.	
Aurangabad ..	Do.	
Latur ..	Do.	
Barsi ..	Do.	
Sholapur ..	Do.	
Sailu ..	Do.	
Sindewahi ..	Two samples—white (*rambha*) and red (*ghunkia*)	Superintendent, Govt. Farm, Sindewahi.
Nagpur ..	Local seed	Director of Agriculture, Central Provinces.
Hoshangabad ..	Two samples—red and white ..	Superintendent, Govt. Farm, Powarkhera.
Gurdaspur ..	Local seed	Deputy Director of Agriculture, Gurdaspur.
Srinagar ..	Two samples of Kashmir linseed ..	Director of Agriculture, Kashmir.
Pusa ..	Small brown	Villagers near Pusa.

The various samples were sown at Pusa in 1915 and a large number of single plants in each were selected and allowed to flower under muslin bags. The seeds of these plants were then sown in 1916 and single plants were again bagged. This procedure was continued for several years. The elementary species which remained after eliminating heterozygotes, were then studied and classified. At the same time the pollination of the flower was examined in detail and the amount of natural crossing determined. Some attention has been paid to the root system, to the effect of soil conditions on the growth of this crop and to the economic aspect. It has been possible to find among the types isolated some of great agricultural promise.

II. GENERAL BIOLOGY.

1. THE RELATION BETWEEN SOIL FACTORS AND THE TYPE OF LINSEED CULTIVATED.

Great differences have been observed between the types of linseed grown on the soils of Peninsular India (south of the line of the Ganges and the Jumna) and those cultivated on the Gangetic alluvium.

The types of the Peninsula grow very rapidly at first at Pusa and the early formed leaves are large. The plants, however, lack vegetative vigour; branching is sparse; the stems soon become weak and procumbent and the early foliage is rapidly shed. This weakness in the stem persists throughout the growing period and at flowering time these sprawling plants stand out in strong contrast to the vigorous, erect types of the alluvium. The comparatively feeble growth of these forms is associated with very deep root development. All form large seeds rich in oil.

The varieties from the alluvium grow comparatively slowly at first but the stems are strong and rarely become procumbent. They are much branched and form abundant seed which is generally small and poorer in oil than in the Peninsular types. There is no loss of foliage and no sign of disease. The root system is usually shallow and abundant. In Fig. 1 the root systems of the

FIG. 1. Linseed from Central India (left) and the Indo-Gangetic alluvium (right).

two groups of linseed are shown. It will be seen that in the Peninsular type branching does not occur until the taproot has penetrated to some distance whereas in the type from the alluvium branching begins at once.

SECONDARY FLOWERING IN LINSEED.

Type 29 (left) shows secondary flowering and the corresponding root development. These are absent in Type 34 (right).

The effect of long continued natural selection on the botanical composition of a crop is strikingly illustrated by the Indian linseeds. The deep rooted, large seeded, rapidly growing types of the Peninsula with few branches are admirably suited to make the most of the soil conditions of this tract where the surface cracks and rapidly dries and where the crop is dependent on the moisture of the lower layers. The growing season is short and soil moisture is apt to be a limiting factor. Rapid growth, few branches and large seeds are therefore obvious agricultural advantages. On the strong moist soils of the alluvium, where the upper layers are constantly moistened by the rise of moisture from the vast sea of underground water which exists about fifteen to twenty feet below the surface, early flowering combined with poor branching would be no advantage. There is ample time and sufficient moisture for extensive root development and for the maximum production of seed. This is confirmed by the yields obtained when unit species of these two groups are grown at Pusa. Even the best of the Peninsular types never produce the weight of seed given by the elementary species of the alluvium. The particular type of linseed grown in these two areas has obviously been determined by the soil factors.

2. Secondary flowering.

The effect of the type of root development on the sharpness of ripening is another interesting point which arose during the course of these investigations. Generally speaking, the varieties in Bihar ripen off sharply and definitely during the early part of the hot weather (15th March to 15th April). The exact time of ripening depends, as in other crops, on the advent and intensity of the hot winds which are prevalent at this season.

In most of the unit species of linseed, flowering ceases before the first formed capsules change colour. The sequence of maturation is as follows. The capsules ripen, turn brown and dry up first, then the upper branches turn brown and finally the main stem and basal branches lose their green colour and become dry. In certain types, however, although the capsules turn brown, the stems and branches retain their green colour and a second growth begins *after* the first set of capsules is ripe. The flowering is not continuous, the second flowering only starting after an interval. Such types flower, set seed and ripen their capsules in the ordinary manner and then, when the stems would normally turn brown, new leaves and flowers develop. The new growth and the whole plant eventually dries up owing to the increasing temperature and dryness. The young leaves and flowers with the ripe capsules growing side by side are shown in Plate I. The amount of secondary flowering varies in

different years and appears to depend on the amount of moisture in the soil. In 1923, a year in which the soil was exceptionally moist and hot winds were absent, this phenomenon was very marked. An examination was made *in situ* of the root systems of types growing side by side, some of which ripened off sharply while the others showed marked secondary flowering. It was found in all the cases examined that this secondary development was correlated with a deep root-system and active roots were found, mainly at a little distance below the surface. The roots in the other type were superficial and already dead. The root systems of these two types are shown in Plate I in which the active roots are represented in red.

In addition to the distribution of the roots it is probable that some other factor such as longevity is involved. The following eight types exhibited secondary flowering in 1923—Types 28, 29, 41, 46, 53, 56, 62 and 63. Six of these are late or very late.

No definite explanation can yet be given to account for the interval between the two periods of flowering. It may either be connected with some upward movement of the sub-soil water or it may be that when the first set of capsules has ripened off and ceases to require water, the small amount of moisture obtainable by the few active roots is just sufficient to re-start growth. Secondary flowering is important from an economic point of view for it is only the types which ripen off sharply which give an even sample and are easily threshed.

3. Soil conditions and growth.[1]

Some observations on the effect of changes in the soil conditions on the growth of linseed have been made in connection with certain experiments originally devised for another purpose.[2] The experiments were carried out in pit cultures[3] during 1921, 1922 and 1923. In 1921, a deep-rooted variety from Peninsular India (Type 94) was grown, in 1922 and 1923 a much branched, shallow-rooted type from the alluvium (Type 12). The effect on the height,

[1] In this section of the work valuable help was given by Babu Kashi Ram, Third Assistant in the Botanical Section, Pusa.

[2] *Agri. Jour. of India*, Special Indian Science Congress number, 1918. p. 36.

[3] In pit cultures, small plots, $5' \times 5'$, are excavated to a depth of $18''$ and the soil of all the plots is mixed, care being taken to keep the sub-soil and surface soil separate. This soil with the necessary additions of leaf-mould and potsherds is then replaced in the pits in as uniform a manner as possible. The pits are filled before the monsoon and the first crop is taken after the rain has consolidated them. This method obviates the well-known difficulties of pot cultures in tropical countries and is the only reliable method of exact field experiment we have discovered in a locality where the soil is so variable as at Pusa.

number of basal branches and yield of the addition of potsherds (to increase the æration), sodium nitrate and organic matter is shown in Tables II, III and IV. The leaf-mould and potsherds were added to the soil in 1919 once for all when the pits were filled. Sodium nitrate is added every year just before sowing by sprinkling it on the surface and mixing it with the upper soil. A crop of indigo was grown during 1919 and 1920 followed by linseed in 1921, 1922 and 1923

TABLE II.

The effect of soil aeration and organic matter on the height of linseed.

Soil treatment	1921 TYPE 94					1922 TYPE 12		1923 TYPE 12			
	No. of plants *	Average height in cm.				No. of plants	Average height in cm.	No. of plants	Average height in cm.		
		15-12-20.	10-1-21.	31-1-21.	At harvest		At harvest		28-11-22.	13-12-22.	At harvest
Control	27	13·6	28·9	44·3	47·7	143	51·6	98	9·0	17·8	62·6
Sodium nitrate @ 4 cwt. per acre	35	14·3	29·6	46·7	53·6	143	61·1	95	11·0	20·0	65·0
Soil $\frac{9}{10}$ + potsherds $\frac{1}{10}$ ..	36	12·4	28·8	44·7	49·3	146	50·0	98	9·3	17·6	61·3
Soil $\frac{8}{10}$ + potsherds $\frac{2}{10}$ ..	37	13·7	28·6	45·1	51·0	145	50·9	99	9·9	21·4	63·1
Soil $\frac{7}{10}$ + potsherds $\frac{3}{10}$ ..	34	15·4	33·0	47·7	53·7	144	53·2	98	10·8	21·4	64·8
Soil $\frac{7}{10}$ + leaf-mould $\frac{3}{10}$ ..	39	15·4	36·0	53·4	56·8	146	73·0	100	12·6	23·4	81·2
Soil $\frac{6}{10}$ + leaf-mould $\frac{3}{10}$ .. + potsherds $\frac{1}{10}$	38	15·1	37·6	55·4	60·6	146	69·8	28†	12·7	23·7	78·1
Soil $\frac{5}{10}$ + leaf-mould $\frac{3}{10}$ .. + potsherds $\frac{2}{10}$	37	16·2	37·9	57·9	65·1	146	75·7	101	13·0	24·2	80·4
Soil $\frac{4}{10}$ + leaf-mould $\frac{3}{10}$ .. + potsherds $\frac{3}{10}$	35	16·2	37·3	55·3	61·1	143	76·3	100	12·5	23·0	79·9

* This gives the number of plants measured, the actual number of plants per plot was 80.

† This plot was very badly attacked by white ants (*Termites*).

TABLE III.

The effect of soil aeration and organic matter on the branching of linseed.

Soil treatment	1921 TYPE 94		1922 TYPE 12		1923 TYPE 12			
	No. of plants	AVERAGE NUMBER OF BRANCHES	No. of plants	AVERAGE NUMBER OF BRANCHES	No. of plants	AVERAGE NUMBER OF BRANCHES		
		At harvest		At harvest		2-11-22	13-12-22	At harvest
Control	27	1·4	143	6·2	98	1·6	4·1	6·4
Sodium nitrate @ 4 cwt. per acre	35	2·0	143	7·1	95	1·5	4·0	7·7
Soil $\frac{9}{16}$ + potsherds $\frac{1}{16}$ ..	36	1·7	146	6·8	98	1·6	5·4	7·5
Soil $\frac{8}{16}$ + potsherds $\frac{2}{16}$ ..	37	2·0	145	7·3	99	1·6	5·7	7·9
Soil $\frac{7}{16}$ + potsherds $\frac{3}{16}$ ..	34	2·2	144	6·8	98	1·8	5·6	9·1
Soil $\frac{7}{16}$ + leaf-mould $\frac{3}{16}$ ..	39	4·7	146	10·2	100	2·7	9·1	11·3
Soil $\frac{6}{16}$ + leaf-mould $\frac{3}{16}$ .. + potsherds $\frac{1}{16}$	38	4·8	146	10·3	28	2·8	9·4	12·1
Soil $\frac{5}{16}$ + leaf-mould $\frac{3}{16}$ .. + potsherds $\frac{2}{16}$	37	5·5	146	10·0	101	2·8	8·0	11·5
Soil $\frac{4}{16}$ + leaf-mould $\frac{3}{16}$ .. + potsherds $\frac{3}{16}$	35	4·7	143	9·9	100	2·2	8·0	10·8

Table IV.

The effect of soil aeration and organic matter on the yield of linseed.

Soil treatment	1921 Type 94			1922 Type 12			1923 Type 12		
	No. of plants	Actual yield gms.	Yield per 36 plants gms.	No. of plants	Actual yield gms.	Yield per 140 plants gms.	No. of plants	Actual yield gms.	Yield per 100 plants gms.
Control	27	53	52	143	208	204	98	403	415
Sodium nitrate @ 4 cwt. per acre ..	35	82	84	143	292	286	95	557	586
Soil $\frac{9}{10}$ + potsherds $\frac{1}{10}$ ..	36	76	76	146	207	199	98	413	421
Soil $\frac{8}{10}$ + potsherds $\frac{2}{10}$ ..	37	89	87	145	238	230	99	437	441
Soil $\frac{7}{10}$ + potsherds $\frac{3}{10}$ ..	34	91	96	144	226	220	98	463	472
Soil $\frac{7}{10}$ + leaf-mould $\frac{3}{10}$ ..	39	163	150	146	517	496	100	980	980
Soil $\frac{6}{10}$ + leaf-mould $\frac{3}{10}$ + potsherds $\frac{1}{10}$ ..	38	176	167	146	448	430	28	249	889
Soil $\frac{5}{10}$ + leaf-mould $\frac{3}{10}$ + potsherds $\frac{2}{10}$ ..	37	224	218	146	515	494	101	868	859
Soil $\frac{4}{10}$ + leaf-mould $\frac{3}{10}$ + potsherds $\frac{3}{10}$ ..	35	177	182	143	413	404	100	847	847

TABLE V.

The development of nitrates in the experimental linseed plots.[1]

Soil treatment	Time of sampling	Moisture %			N as NO_3 in parts per million			N as NO_3 in pounds per acre		
		0-6″	6″-12″	12″-18″	0-6″	6″-12″	12″-18″	0-6″	6″-12″	12″-18″
Sodium nitrate @ 4 cwt. per acre	1st week, December 1920	12·10	11·96	11·87	31·83	1·24	0·79	43·23	1·67	1·08
	1st week, January 1921	6·32	9·43	10·21	33·44	0·43	2·07	45·42	0·58	2·81
	1st week, February 1921	6·43	8·30	8·98	37·58	0·42	0·34	51·03	0·57	0·46
Control	1st week, December 1920	12·43	11·70	12·14	2·75	1·06	0·53	3·74	1·43	0·72
	1st week, January 1921	7·19	9·49	10·58	2·39	0·43	0·43	3·25	0·58	0·58
	1st week, February 1921	10·19	8·53	9·93	1·21	0·34	0·17	1·64	0·46	0·23
Soil $\frac{7}{10}$ + potsherds $\frac{3}{10}$	1st week, December 1920	11·57	14·32	13·18	3·34	1·78	0·81	4·53	2·36	1·10
	1st week, January 1921	7·78	11·77	10·50	1·08	0·44	0·35	1·47	0·60	0·47
	1st week, February 1921	6·29	9·62	10·89	2·20	0·34	0·87	2·99	0·46	1·18
Soil $\frac{7}{10}$ + leaf-mould $\frac{3}{10}$	1st week, December 1920	15·24	18·51	18·29	21·28	26·23	29·05	28·9	35·62	39·45
	1st week, January 1921	9·47	13·35	15·20	20·45	19·81	22·19	27·77	26·90	30·14
	1st week, February 1921	7·25	11·75	11·48	22·72	29·04	28·92	30·86	39·43	39·28
Soil $\frac{4}{10}$ + leaf-mould $\frac{3}{10}$ + potsherds $\frac{3}{10}$	1st week, December 1920	16·34	18·35	19·80	12·22	18·90	35·67	16·60	25·67	48·43
	1st week, January 1921	11·72	16·49	19·31	18·47	13·20	22·62	25·08	17·92	30·71
	1st week, February 1921	10·13	14·15	16·32	23·22	18·67	22·56	31·53	22·35	30·64

Table V shows the amount of nitrogen present at the depth of 6″ 12″ and 18″ in the various plots.

It will be seen that the results of the three years are very consistent. The addition of aerating material causes a small increase in the height and in the number of branches. The increase in these two characters produced by the addition of 30 per cent. of aerating material is roughly equivalent to the in-

[1] These determinations were carried out by Mr. A. V. Iyer with the kind permission of Mr. F. J. Warth, Offg. Imperial Agricultural Chemist.

crease produced by the sodium nitrate. Sodium nitrate, however, has a much greater effect on the yield of seed. The most striking result is produced by the addition of organic matter either by itself or in conjunction with aerating material. The addition of 30 per cent. of leaf-mould has produced an increase of approximately 30 per cent. in the height, 100 per cent. in the number of basal branches and 250 per cent. in the weight of seed.

III. BIOLOGY OF THE FLOWER.

1. Flowering.[1]

The flowers open in the early morning and, as a general rule, in all such buds the folded corolla is visible the evening before. In rare cases, however, a flower opens in which the corolla is not apparent the previous evening. When the corolla becomes visible, the filaments are still short and the unburst anthers stand well below the slightly twisted stigmas. The rapid growth of the filaments, however, soon brings the anthers to the same level as the stigmas and this is the position when opening begins. The time of opening of the flowers depends chiefly on the temperature and humidity and to a less extent on the particular type. On warm mornings and when there is little or no dew, opening begins very early, while on cold dewy mornings the process is distinctly delayed.

In February 1916, the following observations were made on this point :—

Table VI.

Observations on the time of opening and closing of the flowers.

(1) February 9th. A cold day (max. temp. 70°F. ; min. temp. 30°F. ; temp. at 8 A.M. 47°F.).

No. of flower	Time of bursting of anthers	Time when opening of the flower was completed	Time of closing or shedding of petals	Time of re-opening of the flower the following day
1	9–59	11–15	16–30	10–12
2	10–00	10–55	16–30	10–13
3	9–58	11–20	16–30	10–11
4	9–52	11–30	16–30	10–10
5	9–56	11–45	16–30	10–05
6	9–52	12–00	16–30	10–08
7	9–51	11–25	15–40	....
8	9–37	10–45	16–30	9–46
9	9–00	10–47	16–30	10–02
10	9–42	10–58	16–00	....
11	9–39	11–43	15–45	....
12	9–30	10–45	16–30	9–40

[1] Howard and Howard, *Memoirs of the Dept. of Agri., Bot. Ser.*, X, 1919, p. 208.

(2) February 6th. A warm day (max. temp. 86°F.; min. temp. 53°F. temp. at 8 A.M. 61°F.).

No. of flower	Time of bursting of anthers	Time when opening of the flower was completed	Time of closing or shedding of petals	Time of re-opening of the flower the following day
1	8–15	8–31	17–00	8–00
2	8–31	8–40	16–00	....
3	8–12	8–29	14–30	....
4	8–15	8–27	16–00	....
5	8–59	8–27	16–00	....
6	8–24	8–35	15–00	....
7	8–14	8–40	13–30	....
8	8–15	8–40	14–30	....
9	8–13	8–36	13–30	....
10	8–08	8–27	15–00	....
11	8–13	8–40	13–30	....
12	8–17	8–33	13–00	....

Thus the opening is not only delayed on cold days but flowers often re-open the following morning and the petals do not fall till the second day. On February, 10th 1916, a very warm day, some flowers began to show signs of opening as early as 3 A.M., while on February 9th, a cold day, opening did not begin till 7-30 A.M. As a rule the flowers are fully open between 8-15 and 9 A.M. on normally warm days, and from 10 A.M. to 12 noon on cold days. The petals begin to fall on the day of opening and this is generally completed by 5 P.M. A few, however, re-open the following morning and the number is considerably increased on cold and cloudy days.

Observations on the flowering and pollination of European forms of *L. usitatissimum*, grown for fibre, have been published by Fruwirth.[1] A very full account of the morphology of the flower and of the details of flowering and pollination of such varieties has been recorded by Tammes.[2] The time of opening of the flower appears to differ considerably in Holland and in Bihar. Thus Tammes states that in the former country the flowers begin to open at 5 A.M. and to fall at 10 or 11 A.M. It is unusual to find a single flower after noon. She also states that the re-opening of the flower on the following day is extremely rare. Apparently the length of time the flower remains open is approximately the same as in India—about 5 hours.

2. Pollination.

The anthers begin to burst longitudinally when the flower is half open and at this period they stand at a little distance from the crowded stigmas and

[1] Fruwirth, C., *Die Züchtung der landw. Kulturpflanzen*, III, 1922, s. 45.

[2] Tammes, T., *Recueil des travaux botaniques Neérland.*, XV, 1918, p. 185.

INDIAN LINSEED.

1, a complete plant in flower. 2, a bud at 5 p. m. the day before opening. 3, an opening bud at 6-30 a. m. 4, a fully opened flower at 8 a. m. 5, self pollination at 9 a.m. 6, the style at 12 noon.

often at a slightly higher level (Plate II). A few minutes later when the flower is fully open and the rupture of the anthers is complete, they close in on the stigmas and self-pollination takes place. Thus self-pollination takes place automatically by the help of the expansion of the corolla. At a little later stage, the burst anthers often fall together forming a cap over the stigmas a movement which renders self-pollination a practical certainty. In many flowers it was observed that after the anthers begin to burst, twisting of the styles occurred which helped to move the burst anthers through 90° thus bringing their pollen-covered surfaces close to the stigmas. This twisting also brought the stigmas to a slightly lower level and so assisted the burst anthers to fall together and form a cap over the stigmas. In many cases these styles untwist after the anther cap is formed, a circumstance which still further favours self-pollination (Plate II).

3. Cross-fertilization.

Small bees visit the flowers for honey about 10 A.M. While collecting honey from the five nectaries, they occasionally come in contact with the burst anthers and with the stigmas so that cross-pollination is possible. That crossing may occasionally take place in India has been proved by a study of the cultures obtained from the seed of single plants.[1] In 1916, the seed of 340 bagged plants was sown of which 334 appeared to breed true. Splitting was observed in six cultures only—one gave rise to plants with flowers of different shades of blue while five cultures produced plants differing in habit of growth. In 1917, the seed of 233 bagged plants was sown. All seemed to breed true except one which split as regards habit and flower colour. In 1918, the seed of 232 bagged plants was sown all of which appeared to breed true. These observations indicate that in the field crossing is more frequent than would be suspected from a study of the flower. That this is so was confirmed by the results of sowing separately the unbagged seed of all the cultures raised in 1917. In these 233 cultures, stray plants were found in five cases as follows :—

No. 1 (white flowers). Two blue-flowered plants appeared which next year gave 84 blue and 32 white flowered plants in one case and 129 blue and 34 white in the other, or a total of 213 blues to 66 whites.

No. 23 (white flowers). One blue-flowered plant occurred which gave next year 52 blue-flowered and 12 white-flowered plants.

No. 165 (white flowers). One blue-flowered plant was found which next year gave 84 blue-flowered and 19 white-flowered offspring.

[1] For previous observations on the occurrence of natural cross fertilization at Pusa see *Mem. of the Dept. of Agri., Bot. Ser.*, III, 1910, p. 316.

No. 170 (pale blue flowers). One dark-blue flowered plant appeared which split as regards shape of petals, colour of pollen (white or yellow) and colour of petals—white and shades of blue from very pale to very dark blue. The ratio of total blues to whites was 264 : 7.

No. 217 (blue flowers). In this, three pale blues appeared which split next year into 8 blue and 348 pale blue, 4 blue and 133 pale blue and 4 blue and 276 pale blue.

A similar experience occurred in 1918. In 232 cultures from unbagged seed, a total of 15 stray plants were found in nine of these cultures. In all probability many of these were natural crosses.

These examples are sufficient to show that natural crossing is more common in Indian linseed than would be supposed from a study of the flower. The cases are sufficiently numerous to make it clear that in exact work with this crop all seed must be raised under bag. This does not interfere with setting and as far as our observations go there is no falling off in vigour produced thereby.

The mode of pollination of the European cultivated forms of linseed has been described in detail by Fruwirth[1] who found that self-pollination is the rule and that good setting is obtained under bag without loss of vigour in the succeeding generations. Less produce per plant is however obtained under bag than from free flowering plants. Vargas Eyre and Smith[2] have recently paid some attention in Great Britain to the mode of pollination in various species of *Linum* and sum up their results as follows :—" The flaxes are sometimes regarded as ' selfing ' so readily that there is small chance of cross-pollination being effective. It seems quite clear, however, from the foregoing observations that this is not always the case and does not apply to the varieties of *L. usitatissimum* commonly grown and this view receives support from the fact that dimorphism occurs among the species of *Linum*. It is noticed that the pollen is somewhat adhesive in character and is produced only in relatively small quantities and it seems highly probable that the crossing which takes place is almost entirely caused by the insects which may be observed visiting the flowers freely." Bateson,[3] in experiments at the John Innes Horticultural Institute, found self-pollination to be the rule. Tammes[4] also records the occurrence of cross-fertilisation but states that it is infrequent.

[1] Fruwirth, *Die Züchtung der landw. Kulturpflanzen*, III, 1922, s. 45.
[2] Eyre, J. V. and Smith, G., *Jour. of Genetics*, V, 1916, p. 189.
[3] Bateson, W., *Jour. of Genetics*, V, 1916, p. 201.
[4] Tammes, T., *Recueil des travaux bot. Neérland.*, XV, 1918.

Parthenocarpy has been observed in *L. usitatissimum* by Tammes[1] especially where species hybridization was attempted. Parthenogenesis does not appear to occur.

IV. CLASSIFICATION AND DESCRIPTION OF THE TYPES.

The examination of the Indian linseed crop has revealed a surprisingly large number of forms. These differ mainly in the amount and tone of the colour on the various organs of the flower. This colour (which is always some shade of blue or purple) is found on the filaments, anthers, styles and stigmas in addition to the corolla. Thus the filament may be entirely white or may be partly coloured, the tone varying from the palest blue to the deepest purple and the colour may be present in amounts varying from a small dot immediately below the anther to a coloration of the whole of the upper half of the filament. Similarly the amount of colour on the style may vary from a few blue lines to a complete deep blue coloration even extending to the stigma. Pure line cultures during a number of years have shown that the types breed true to minute differences of colour on the essential organs and that these can be safely used for classification purposes.[2]

It has not been considered advisable to make use of the European varieties proposed by Alefeld.[3] In the first place, the short, much branched Indian linseeds form a group quite distinct from the tall European forms. Secondly, the meagre descriptions which ignore the colour on the essential organs would make any assignment of doubtful value. The Indian linseeds have, therefore, been considered as a separate group and a classification based on easily recognizable morphological differences is given in this paper. The 121 elementary species isolated fall into 26 varieties. The characters used in differentiating the varieties are the colour of the seeds, corolla, filaments, anthers and styles and the size of the seeds. In general, it is a somewhat doubtful procedure to use size differences as varietal distinctions. The differences in the size of the seed in Indian linseeds are, however, so well marked that they form the basis of the commercial classification, which recognizes three classes—bold, medium and small. The types have been separated in the first instance by differences in the amount and tone of colour of the filaments, anthers, styles, stigmas and seeds. Habit differences, which naturally depend on environment, have only been used as a last resort.

[1] Tammes, T., *Recueil des travaux bot. Neérland.*, XV, 1918.

[2] See also Tammes, T., *Jour. of Genetics*, XI, 1922, p. 20.

[3] Alefeld—*Landw. Flora*, p. 102. We are much indebted to Dr. Carl Fruwirth, Professor at the Technische Hochschule, Vienna, for a transcript of these descriptions as the book was unobtainable in India.

1. Notes on the characters.

Habit. The general habit depends on three things—the height, the mode of branching and the foliage. The heights of the various unit species in 1923 varied between 41 and 71 cm. and as a general rule this character is not greatly influenced by the environment. Very tall forms, such as those grown in Europe, are not represented among the indigenous types. The Indian forms branch both from the base and also at a point higher up on the stem. The basal branches may be crowded giving an erect, compact appearance to the culture or they may be spreading when the plants possess an open habit of growth. As would be expected, the amount of branching is not constant but varies greatly according to the fertility of the soil. The potential branching power of a type is, however, a definite inherited character. In 1921, the average number of basal branches varied from two to fourteen among the 121 types when grown under equal conditions. The leaves in all cases are linear with smooth surfaces. In 1921, the length varied from 2·2 to 4·3 cm. and the breadth from 0·2 to 0·7 cm. There is some range in the colour of the foliage from green to bluish green but this is not considerable.

Period of growth. The types show very great differences in the length of the growth period and these differences can be utilized in classification. The seeds of the earliest kinds are nearly ripe before the late ones begin to flower. In 1923, the earliest type began to flower 47 days, the latest 81 days after sowing.

Flowers. There is a considerable range in the size of the flowers of the types, in the degree of opening and in the details of colouring. The petals vary from sub-linear to broad in which the length and breadth are equal. They fall into two classes—those with narrow and those with broad petals. The differences in the expansion of the flower between the types is considerable. In fully opened flowers with narrow petals, a certain amount of space is left between the petals whereas when the petals are broad they overlap forming a continuous corolla. The amount of opening of the flower also varies. There is every gradation between fully opened flowers and those which are only half open. A further complication occurs through the incurving of the edges of the petals or the folding of the whole petal. Although the amount of opening of the flowers and the degree of folding of the petals varies to some extent with the weather, nevertheless these differences are also characteristic of the types. The differences in flower colour depend on the general ground colour of the petals and also on markings which spread in a fan-shaped form from the base of the petal. These markings are due to the presence of a dark colour in the

veins, mostly in the lower part of the petal. In some flowers, as in Type 4, these are of the same colour as the petal and therefore inconspicuous; in others, they are darker in colour than the petal and are, therefore, conspicuous. This is particularly the case in Types 1, 2 and 3 where the markings are violet and the petals are white. In the corolla two colours—blue and pink—exist in varying proportions. The petals may be:—

(*a*) White—opaque pure white or semi-transparent bluish white.

(*b*) Pale blue—in which case the pink colour is absent or else very faint.

(*c*) Blue—in which case blue is predominant but with the pink factor present. There is a considerable range in blues.

(*d*) Violet. In these, pink predominates although blue is also present. The violet tones range from a bluish pink to a decided purple.

The presence of both blue and pink can be seen by the naked eye. Tammes[1], in a series of investigations, the results of which are summed up in a recent paper published in the *Journal of Genetics*, has identified six factors which influence the colour of the corolla. She has also been able to isolate a form with a pink corolla. This is not represented in India.

Andrœcium. The various parts of the stamens, including the pollen, exhibit interesting colour differences. The filaments are either white or white with various amounts of blue or purple. The colour may occur on one side of the filament only or may be diffused over the whole surface. In the latter case, various stages from a ring just below the anther to a complete coloration of the upper half of the filament can be found. Similarly, in the former case the amount varies from a dot immediately below the anther to a strip half the length of the filament. All stages of colour from pale blue through blues (including bright blue) to purple are represented. There is a similar range of colour in the anthers but these appear to show no connection with the colour scheme of the filament. The anthers are either white or white with a blue line or blue. Blue anthers may occur with white or with purple filaments. Examples of the various combinations may be seen in Plate III. The combination of pale blue anthers with purple filaments presents a very striking appearance.

The pollen appears white or of various shades of yellow but this difference is accentuated by the colour of the anther. A blue anther wall lessens the yellow appearance while a white wall intensifies it. This character has, therefore, not been used in the classification. No blue pollen such as occurs in the

[1] Tammes, T., *Jour. of Genetics*, XII, 1922, p. 19.

European forms has been observed. In a paper by Tammes[1] it is stated :— "In the blue anther, however, both wall and pollen are blue. Whether there are forms in which the pollen is yellow and the wall blue or the pollen blue and the wall colourless I have not yet investigated." The Indian linseeds give a large number of examples of the former (pollen yellow, wall blue) but none of the latter combination (pollen blue, wall colourless). In the present paper, the term ' anther blue ' refers only to the colour of the wall of the anther.

Gynœcium. The styles are either white or white with varying amounts of blue or purple. In contrast with the filaments the colour always spreads from the base upwards. The range is shown in Plate III.

The stigmatic surfaces are either white or purple or white tinged with varying amounts of pink or purple. The colour of the stigma is best seen under a lens when the flowers are receptive. This is a somewhat difficult character to determine as it changes with the age of the flower. The stigma is never coloured if the style is white, neither is a deep purple stigma ever found with a pale blue style. It may be said generally that the intensity of the colour of the stigma is always less than that of the style.

Seeds. The seeds vary in colour from pure yellow to brown. Two grades of yellow—pure yellow and yellow with a brownish tinge—and two grades of fawn can be distinguished. These facts and the occurrence of various degrees of brown suggest that several factors are likely to be involved in producing the deepest shades of brown. Tammes[2] states that the brown colour of the seed coat is produced by a complex of characters and that the yellow appearance of the seeds is due to the yellow colour of the cotyledons appearing through the colourless and transparent seed coat of those forms. Large seeded types occur in all these colours but the medium and small types are only associated with a brown seed coat. Investigations have shown that probably several factors are concerned in the determination of the size of the seeds.[3]

Correlations. It is of interest to see what evidence is afforded by this collection of linseeds on the question of correlation as regards colour among the parts of the flower. The following table shows that the colour of the corolla can be equally well associated with coloured or with white filaments, anthers and styles. Whether this independence is only apparent and is due to the presence of inhibiting factors in the various parts can only be determined by investigation of the genetics of this species.

[1] Tammes, T., *Jour. of Genetics,* XII, 1922, p. 19.
[2] Tammes, *loc. cit.*
[3] Tammes, T., *Rec. des. travaux bot. Neér,* VIII, 1911.

COLOUR DISTRIBUTION IN THE STAMENS AND STYLES OF LINSEED.

TABLE VII.

Correlation of characters.

A white corolla may be present with—	A blue corolla may be present with—
white or blue filaments	white or blue filaments
white or blue anthers	white or blue anthers
white or blue styles	white or blue styles
yellow, fawn or brown seeds	fawn or brown seeds
small or bold seeds	small, medium or bold seeds

A lilac or purple corolla may be present with—
blue filaments
blue or white anthers
blue style
fawn or brown seed
small or bold seed

It is probably a chance that no medium-sized seeds are associated with white or lilac corollas as both small and bold seeds occur. The association of yellow seeds with a white corolla only may be also a coincidence as Tammes[1] has found blue-flowered, yellow-seeded linseeds. No connection can be traced between the colour of the anthers and that of the filaments and styles. White and blue anthers are found associated with both blue and white filaments and blue and white styles. White filaments occur with both white and blue styles. Blue filaments only occur with blue styles but this may be accidental. A correlation which will probably be found to be a true one is, however, the association of a coloured stigma only with a coloured style. In general, the examination of these Indian linseeds would point to the independence of the colour manifestations on the various parts of the flower.

2. KEY TO THE INDIAN VARIETIES OF L. USITATISSIMUM.

I. Seeds yellow.
1. Corolla white.
A. Anthers white.
(*a*). Filaments blue.
a. Styles blue.
(1). Seeds bold.
var. *luteum*.
Types 1, 2, 3.

[1] Tammes, T., *Jour. of Genetics*, XII, 1922, p. 19.

II. Seeds fawn coloured.
1. Corolla white.
A. Anthers white.
(*a*). Filaments blue.
a. Styles pale blue.
(1). Seeds bold.
var. *lutescens*.
Types 4, 5.
2. Corolla light blue.
A. Anthers blue.
(*a*). Filaments pale blue.
a. Styles pale blue.
(1). Seeds bold.
var. *indicum*.
Type 6.
3. Corolla blue.
A. Anthers blue.
(*a*). Filaments blue.
a. Styles blue.
(1). Seeds bold.
var. *cyaneum*.
Types 7, 8, 9, 10.
4. Corolla deep purple.
A. Anthers blue.
(*a*). Filaments blue.
a. Styles blue.
(1). Seeds bold.
var. *purpureum*.
Type 11.

III. Seeds brown.
1 Corolla white.
A. Anthers white.
(*a*). Filaments white.
a. Styles white.
(1). Seeds small.
var. *albidum*.
Type 12.
(2). Seeds bold.
var. *album*.
Types 13, 14.

B. Anthers blue.
(*a*). Filaments white.
α. Styles white.
(1). Seeds small.
var. *albocæruleum*.
Type 15.

2. Corolla light blue.
A. Anthers white.
(*a*). Filaments blue.
α Styles blue.
(1). Seeds medium in size.
var. *officinale*.
Types 16, 17, 18.

B. Anthers blue.
(*a*). Filaments white.
α. Styles white.
(1). Seeds small.
var. *bengalense*.
Types 19, 20.
(2). Seeds bold.
var. *agreste*.
Types 21, 22.

β. Styles pale blue.
(1). Seeds small.
var. *meridionale*.
Type 23.

(*b*). Filaments blue.
α. Styles blue.
(1). Seeds small.
var. *gangeticum*.
Type 24.
(2). Seeds medium in size.
var. *laxum*.
Types 25, 26.
(3). Seeds bold.
var. *præcox*.
Type 27.

3. Corolla blue.

A. Anthers white.

(*a*). Filaments white.

a. Styles blue.

(1). Seeds small.

var. *pratense*.

Type 28.

(*b*). Filaments blue.

a. Styles blue.

(1). Seeds small.

var. *minor*.

Types 29, 30, 31, 32.

(2). Seeds bold.

var. *herbaceum*.

Type 33.

B. Anthers blue.

(*a*). Filaments white.

a. Styles blue.

(1). Seeds small.

var. *pulchrum*.

Type 34.

(2). Seeds medium in size.

var. *cæsium*.

Type 35.

(3). Seeds bold.

var. *bicolor*.

Type 36.

(*b*). Filaments blue.

a. Styles blue.

(1). Seeds small.

var. *commune*.

Types 37 to 62.

(2). Seeds medium in size.

var. *campestre*.

Types 63 to 80

(3). Seeds bold.

var. *vulgatum*.

Types 81 to 117.

4. Corolla purple.
   A. Anthers white.
      (*a*). Filaments blue.
         a. Styles blue.
            (1). Seeds bold.
               var. *tinctorium*.
                  Types 118 to 120.
   B. Anthers blue.
      (*a*). Filaments blue.
         a. Styles blue.
            (1). Seeds small.
               var. *sativum*.
                  Types 121 to 123.

3. Description and key to the Types.

var. LUTEUM.

Seeds yellow, bold. *Corolla* white with violet markings. *Stamens* anthers white, filaments blue. *Styles* blue.

1. Seeds pure yellow.

Type 1. Early, most of the branching at the base giving an open habit; average height 49 cm. *Foliage* light bluish green. *Flowers* very large, open; petals broad; filaments upper half blue; styles blue at the base, white above, stigmatic surfaces white with a pink tinge.

2. Seeds yellow with a brownish tinge.

Type 2. Very early, spreading, a medium amount of branching; average height 50 cm. *Foliage* light bluish green. *Flowers* large, open; petals broad; filaments upper half blue; styles blue below, white above, stigmatic surfaces white with a pink tinge.

Type 3. Medium in maturity, a medium amount of branching, open in habit; average height 56 cm. *Foliage* light bluish green. *Flowers* very large, open; petals broad; filaments upper half blue; styles blue below, white above, stigmatic surfaces white with a pink tinge.

These two types differ in the time of maturity and in the size of the flower.

var. LUTESCENS.

Seeds fawn coloured, bold. *Corolla* white with violet markings. *Stamens* anthers white, filaments blue. *Styles* pale blue.

TYPE 4. Early, habit spreading; average height 48 cm. *Foliage* light bluish green. *Flowers* very large, very open; petals not very road; filaments upper third very pale blue; styles pale blue at the base white above, stigmatic surfaces white. *Seeds* lighter in colour than in Type 5.

TYPE 5. Medium in maturity, a medium amount of branching, open in habit; average height 50 cm. *Foliage* light green. *Flowers* large, very open; petals very broad; filaments upper third very pale blue; styles pale blue at the base, stigmatic surfaces white.

Type 4 is earlier than Type 5, the flowers are larger and the petals less broad with the markings less distinct. The seeds of Type 4 are also lighter in colour.

var. INDICUM.

Seeds fawn coloured, bold. *Corolla* light blue. *Stamens* anthers blue, filaments pale blue. *Styles* pale blue.

TYPE 6. Early, a good deal of branching from the base, open in habit; average height 49 cm. *Foliage* light green. *Flowers* medium in size, open; petals narrow; a clear blue of a light tone with very little pink colour present; filaments upper third pale blue; styles very pale blue, stigmatic surfaces white.

var. CYANEUM.

Seeds fawn coloured, bold. *Corolla* blue. *Stamens* anthers blue, filaments blue. *Styles* blue.

TYPE 7. Medium in maturity, a certain amount of branching from the base, habit erect; average height 49 cm. *Foliage* light bluish green. *Flowers* fairly large, open; petals broad, somewhat deep blue; filaments upper third pale blue, the colour mostly on one side; anthers pale blue; styles pale blue; stigmatic surfaces white with pink tips. *Seeds* yellowish in tone.

TYPE 8. Early, a good deal of branching both above and below, habit open but crowded; average height 47 cm. *Foliage* light green. *Flowers* medium-sized, open; petals narrow, a medium deep blue; filaments upper half blue; styles blue, stigmatic surfaces white, tips pink.

TYPE 9. Medium in maturity, very little branching from the base, somewhat spreading in habit; average height 48 cm. *Foliage* bluish green. *Flowers* medium in size; petals broad, somewhat deep

blue; filaments upper third blue; styles blue, stigmatic surfaces tinged with pale purple.

TYPE 10. Early, a medium amount of branching below, habit open average height 46 cm. *Foliage* bluish green. *Flowers* medium to small, not quite open; petals narrow, deep blue; filaments upper third bright blue; styles bright blue, stigmatic surfaces and tips purple.

These four types can be most easily distinguished by the depth of colour on the anthers, filaments and styles. In Type 7 this is pale blue, in Types 8 and 9 blue and in Type 10 bright blue with purple stigmatic surfaces. Types 8 and 9 can be separated by the breadth of their petals.

VAR. PURPUREUM.

Seeds fawn coloured, bold. *Corolla* deep purple. *Stamens* anthers blue, filaments blue. *Styles* blue.

TYPE 11. Early, a good deal of branching from the base, habit very open and spreading; average height 43 cm. *Foliage* light bluish green. *Flowers* medium in size, not very open; petals very narrow; filaments white except for a minute amount of blue colour just below the anther on one side only; styles deep blue throughout, stigmatic surfaces pale purple with deep purple tips.

VAR. ALBIDUM.

Seeds brown, small. *Corolla* white with light markings. *Stamens* anthers white, filaments white. *Styles* white.

TYPE 12. Late, much branched, very erect, crowded and compact in habit; average height 53 cm. *Foliage* dark green. *Flowers* small, do not open well; petals very narrow, tinged with blue; styles white, stigmas white.

VAR. ALBUM.

Seeds brown, bold. *Corolla* white. *Stamens* anthers white, filaments white. *Styles* white.

TYPE 13. Late, a small amount of branching below, a great deal above, habit erect, crowded and compact; average height 55 cm. *Foliage* dark green. *Flowers* small, never open fully; petals very narrow and never shed, an opaque white, markings not very apparent; filaments, styles and stigmas white.

TYPE 14. Medium in maturity, a small amount of branching below, a great deal above, habit somewhat spreading and open; average

height 60 cm. *Foliage* bluish green. *Flowers* medium in size, open fully; petals thin, easily shed, white with a bluish tinge, markings faint but distinct, very narrow with very wide spaces in between; filaments, styles and stigmas white.

var. ALBOCŒRULEUM.

Seeds brown, small. *Corolla* white with light markings. *Stamens* anthers blue, filaments white. *Styles* white.

TYPE 15. Somewhat late, much branched, erect and very compact in habit; average height 62 cm. *Foliage* light green. *Flowers* medium in size, mediumly open; petals broad; styles white, stigmas white.

var. OFFICINALE.

Seeds brown, medium in size. *Corolla* pale blue. *Stamens* anthers white, filaments blue. *Styles* blue.

TYPE 16. Medium in maturity, a good deal of branching both above and below, habit somewhat spreading; average height 51 cm. *Foliage* light green. *Flowers* small, mediumly open; petals narrow, with much space in between; filaments with a very small amount of pale blue colour on one side; styles blue, stigmatic surfaces pale purple with purple tips.

TYPE 17. Medium in maturity, very little branching below but a great deal above, habit erect, crowded and compact; average height 57 cm. *Foliage* light green. *Flowers* small, half open; petals narrow; filaments upper third bright blue; styles blue, stigmatic surfaces pale purple, tips purple.

TYPE 18. Late, a fair amount of branching below, habit spreading with an open top; average height 48 cm. *Foliage* dark green. *Flowers* large, open; petals broad; filaments upper third blue; styles blue, stigmatic surfaces white.

In Type 18 the petals are broad, in Types 16 and 17 narrow. These two types can be distinguished by the amount of colour on the filaments. In Type 16 the filaments are almost white, in Type 17 the upper third is blue.

var. BENGALENSE.

Seeds brown, small. *Corolla* pale blue. *Stamens* anthers blue, filaments white. *Styles* white.

TYPE 19. Late, much branched, habit very erect, crowded and compact; average height 55 cm. *Foliage* light green. *Flowers*

medium sized, mediumly open; petals narrow, pale blue, a good deal of white at the base, markings very faint; styles white, stigmas white.

TYPE 20. Early, a medium amount of branching, habit open; average height 54 cm. *Foliage* bluish green. *Flowers* medium sized, mediumly open; petals broad, pale blue, darker in tone than in Type 19 but with less white at the base, markings more distinct; styles white, stigmas white.

These two types can be distinguished by the breadth of the petals which are narrow in Type 19, broad in Type 20.

VAR. AGRESTE.

Seeds brown, bold. *Corolla* pale blue. *Stamens* anthers blue, filaments white. *Styles* white.

TYPE 21. Very early, much branching both below and above, habit open but erect; average height 50 cm. *Foliage* somewhat light green. *Flowers* small, do not open fully; petals narrow, lavender coloured, markings very faint; styles and stigmatic surfaces white.

TYPE 22. Early to medium in maturity, a good deal of branching below, a great deal above, habit somewhat spreading; average height 46 cm. *Foliage* light green. *Flowers* medium in size, mediumly open; petals broad, pale blue but deeper in tone than in Type 21, markings faint but distinct; styles and stigmatic surfaces white.

In Type 21 the petals are narrow and lavender-coloured. In Type 22 broad and pale blue in colour.

VAR. MERIDIONALE.

Seeds brown, small. *Corolla* pale blue. *Stamens* anthers pale blue, filaments white. *Styles* very pale blue.

TYPE 23. Very late, much branched, habit erect, compact and crowded; average height 63 cm. *Foliage* dark green. *Flowers* medium in size, open, with a space between the narrow petals which are pale blue with distinct markings; styles very pale blue at the base only, stigmatic surfaces white.

VAR. GANGETICUM.

Seeds brown, small. *Corolla* pale blue. *Stamens* anthers blue, filaments pale blue. *Styles* blue.

TYPE 24. Late, a medium amount of branching, erect, crowded and compact; average height 57 cm. *Foliage* dark green. *Flowers* large, almost open; petals very narrow and curled at the edge, pale blue with practically no pink colour, markings distinct; filaments upper third pale blue; styles blue, stigmatic surfaces white.

VAR. LAXUM.

Seeds brown, medium in size. *Corolla* pale blue. *Stamens* anthers pale blue, filaments pale blue. *Styles* blue.

TYPE 25. Medium in maturity, a little branching below, a great deal above, habit spreading and open; average height 51 cm. *Foliage* bluish green. *Flowers* medium in size, mediumly open; petals narrow with spaces in between, very pale blue with a faint pink tinge, markings distinct but not prominent; filaments with a small amount of blue colour immediately below the anther; styles pale blue, stigmatic surfaces and tips white.

TYPE 26. Medium in maturity, a great deal of branching both above and below, habit spreading and open; average height 55 cm. *Foliage* light green. *Flowers* large, open, colour pale blue with a pink tinge but deeper in tone than in Type 25 and with more prominent markings, petals broad; filaments with a small amount of pale blue colour on one side at a little distance below the anthers; styles white with blue lines, stigmatic surfaces white, tips pink.

In Type 25 the petals are narrow and the styles pale blue, in Type 26 the petals are broad and the styles white with blue lines.

VAR. PRÆCOX.

Seeds brown, bold. *Corolla* pale blue. *Stamens* anthers faintly blue, filaments blue. *Styles* blue.

TYPE 27. Very early, a small amount of branching below, a great deal above, habit erect and open; average height 46 cm. *Foliage* light green. *Flowers* medium in size, open; petals broad, much deeper in tone than in Types 25 and 26, markings distinct; filaments upper third pale blue; anthers faintly blue; base of style pale blue, stigmatic surfaces white.

VAR. PRATENSE.

Seeds brown, small. *Corolla* blue. *Stamens* anthers white, filaments white. *Styles* blue.

TYPE 28. Late, a medium amount of branching, habit erect and somewhat compact; average height 71 cm. *Foliage* somewhat light green. *Flowers* small, mediumly open; petals narrow; styles blue, stigmatic surfaces white.

var. MINOR.

Seeds brown, small. *Corolla* blue. *Stamens* anthers white, filaments blue. *Styles* blue.

1. **Styles pale blue, stigmatic surfaces white, petals broad.**

TYPE 29. Late, a good deal of branching below, erect and compact in habit; average height 69 cm. *Foliage* somewhat light green. *Flowers* large and very open; petals broad; filaments upper half blue; styles pale blue, stigmatic surfaces white.

2. **Styles blue, stigmatic surfaces white, petals broad.**

TYPE 30. Late, much branching below, somewhat open in habit; average height 54 cm. *Foliage* dark green. *Flowers* large and open; petals broad; filaments upper third blue; styles blue, stigmatic surfaces white.

3. **Styles blue, stigmatic surfaces pale purple, petals narrow.**

TYPE 31. Early to medium in maturity, a fair amount of branching above, habit erect and compact; average height 62 cm. *Foliage* somewhat light green. *Flowers* small, half open; petals narrow somewhat deep blue, markings very distinct owing to a white patch at the base of the petals; filaments upper half blue; styles blue, stigmatic surfaces pale purple.

TYPE 32. Very late, a good deal of branching below, very erect and compact in habit; average height 63 cm. *Foliage* dark green. *Flowers* medium in size, mediumly open; petals narrow with much space in between; filaments with a small amount of blue colour just below the anther; styles blue, stigmatic surfaces pale purple.

Types 31 and 32 can be distinguished from one another by the amount of colour on the filaments.

var. HERBACEUM.

Seeds brown, bold. *Corolla* blue. *Stamens* anthers white, filaments blue. *Styles* blue.

TYPE 33. Early, a good deal of branching below, a great deal above, habit spreading and open; average height 49 cm. *Foliage* bluish green. *Flowers* medium in size, open; petals narrow with spaces in between; filaments upper third blue; styles blue at the base, stigmatic surfaces white tinged with pink.

var. PULCHRUM.

Seeds brown, small. *Corolla* blue. *Stamens* anthers blue, filaments white. *Styles* blue.

TYPE 34. Medium in maturity, a good deal of branching above, compact and erect in habit; average height 61 cm. *Foliage* dark green. *Flowers* large, open; petals broad, light blue in tone, markings distinct; anthers with some pale blue colour; styles blue, stigmatic surfaces purple.

var. CÆSIUM.

Seeds brown, medium in size. *Corolla* blue. *Stamens* anthers blue, filaments white. *Styles* blue.

TYPE 35. Late, much branching below, very spreading in habit; average height 48 cm. *Foliage* dark green. *Flowers* large, mediumly open; petals broad; styles blue, stigmatic surfaces white with pale purple tips.

var. BICOLOR.

Seeds brown, bold. *Corolla* blue. *Stamens* anthers blue, filaments white. *Styles* blue.

TYPE 36. Medium in maturity, a small amount of branching below, a great deal above, habit spreading and open; average height 46 cm. *Foliage* light green. *Flowers* small, do not open well; petals broad, somewhat light in tone; anthers very pale blue; styles tinged with pale blue, stigmatic surfaces white.

var. COMMUNE.

Seeds brown, small. *Corolla* blue. *Stamens* anthers blue, filaments blue. *Styles* blue.

1. Styles white with pale blue lines, stigmatic surfaces pale purple; petals narrow.

TYPE 37. Medium in maturity, a medium amount of branching above, somewhat spreading in habit; average height 63 cm. *Foliage* dark green. *Flowers* medium in size and do not open fully; petals narrow, somewhat dark blue in tone, markings very distinct; filaments with a trace of blue colour just below the anther; anthers pale blue; styles white with pale blue lines on the sides, stigmatic surfaces pale purple.

2. Styles pale blue, stigmatic surfaces white (sometimes tinged with pink or pale purple).

A. *Petals narrow.*

TYPE 38. Medium to late in maturity, erect but with an open habit, a moderate amount of branching above and below; average height 68 cm. *Foliage* dark green. *Flowers* medium in size, open with spaces between the petals which are narrow; filaments pale blue immediately below the anther; styles pale blue, stigmatic surface white with pink tips.

TYPE 39. Medium in maturity, a small amount of branching from the base, very open in habit; average height 56 cm. *Foliage* dark green. *Flowers* small, open; petals narrow with a good deal of space between; filaments bright blue immediately below the anther which is very pale blue; styles pale blue, stigmatic surfaces white with pink tips.

B. *Petals broad.*

(*a*) *Filaments with a small amount of blue just below the anther.*

a. Colour on the filaments in the form of a ring.

TYPE 40. Medium in maturity, a small amount of branching below, somewhat spreading in habit; average height 64 cm. *Foliage* somewhat blue green. *Flowers* large, open; petals broad; filaments with a small amount of bright blue colour immediately below the anther; styles pale blue, stigmatic surfaces white with pink tips.

TYPE 41. Very late, much branching below, very erect, crowded and compact; average height 62 cm. *Foliage* dark green. *Flowers* large, open; petals broad; filaments with small amount of bright blue colour just below the anther; styles pale blue, stigmatic surfaces white with pink tips.

TYPE 42. Medium in maturity, erect and somewhat compact in habit, a medium amount of branching below; average height 55 cm. *Foliage* somewhat dark bluish green. *Flowers* medium in size, do not open well; petals broad; filaments with a small amount of bright blue just below the anther; styles pale blue, stigmatic surfaces white.

Types 40 and 41 are tall, with large, open flowers. They differ in maturity. Type 42 is short with medium sized flowers which do not open well.

β. Colour only on one side of the filament.

TYPE 43. Medium to late in maturity, somewhat spreading in habit, a good deal of branching below; average height 56 cm. *Foliage* dark green. *Flowers* medium in size, do not open well; petals broad; filaments pale blue immediately below the anther but the colour is mostly on one side; styles pale blue, stigmatic surfaces white.

TYPE 44. Medium in maturity, a good deal of branching below, habit somewhat spreading and open; average height 49 cm. *Foliage* light green. *Flowers* large, open; petals broad; filaments bright blue immediately below the anther but the colour is mostly on one side; styles pale blue, stigmatic surfaces white with pink tips.

TYPE 45. Medium in maturity, very little branching below, habit somewhat open; average height 60 cm. *Foliage* bluish green. *Flowers* large, open; petals broad; filaments with a very small amount of deep blue colour immediately below the anther; styles pale blue, stigmatic surfaces and tips white.

In Type 43 the flowers are medium in size and do not open well while the colour on the filaments is pale; in Types 44 and 45 the flowers are large and open and the colour on the filaments is bright. These two types differ in height and habit.

(*b*) *Upper third of the filament bright blue.*

TYPE 46. Late, erect in habit but somewhat open at the base, a good deal of branching below; average height 61 cm. *Foliage* light green. *Flowers* very large, very open, with spaces between the petals; petals broad; filament upper third bright blue; styles pale blue, stigmatic surfaces white with pink tips.

TYPE 47. Medium in maturity, habit spreading at the base and open at the top, a fair amount of branching both above and below; average height 48 cm. *Foliage* somewhat light green. *Flowers* somewhat light in colour, large, open; petals broad; filaments upper third bright blue; styles pale blue, stigmatic surfaces white with pink tips.

TYPE 48. Late, a good deal of branching below, somewhat spreading; average height 60 cm. *Foliage* light green. *Flowers* large, mediumly open; petals broad; filaments upper third bright blue; styles pale blue, stigmatic surfaces white, tips pink.

These three differ in maturity and habit.

3. Styles blue, stigmatic surfaces white sometimes tinged with pink or pale purple.

A. *Petals broad, the colour on the filaments in the form of a ring immediately below the anther.*

TYPE 49. Medium in maturity, a medium amount of branching below, erect in habit; average height 64 cm. *Foliage* bluish green. *Flowers* large, open; petals broad; filaments with a small amount of blue just below the anther; anthers pale blue; styles blue, stigmatic surfaces white with pink tips.

TYPE 50. Late, a good deal of branching below, erect and crowded in habit; average height 51 cm. *Foliage* light green. *Flowers* large, open; petals broad; filaments blue just below the anther; styles blue, stigmatic surfaces and tips white.

TYPE 51. Late, a great deal of branching below, erect, crowded and compact in habit; average height 47 cm. *Foliage* light green. *Flowers* small, do not open fully, petals broad; filaments with a small amount of dark blue colour immediately below the anther; styles blue, stigmatic surfaces and tips white.

In Type 51 the flowers are small and half closed whereas in Types 49 and 50 they are large and open. These two types differ in maturity and habit.

B. *Petals broad, upper third of filaments blue.*

TYPE 52. Late, very little branching below, habit very open; average height 67 cm. *Foliage* dark green. *Flowers* large, not very open; petals broad; filaments upper third bright blue; styles blue, stigmatic surfaces white.

TYPE 53. Very late, a medium amount of branching below, habit erect; average height 60 cm. *Foliage* light green. *Flowers* large, open, light in tone; petals broad with spaces in between; filaments upper third blue; anthers faintly blue; styles a decided blue, stigmatic surfaces white.

TYPE 54. Medium in maturity, a fair amount of branching above, erect and compact in habit; average height 59 cm. *Foliage* somewhat dark bluish green. *Flowers* medium in size, mediumly open; petals broad; filaments upper third blue but on one side only; styles blue, stigmatic surfaces white and tips pink.

In Type 52 the anthers are bright blue, in Types 53 and 54 pale blue. Type 53 is late with open flowers, Type 54 medium in maturity with flowers which do not open well.

C. *Petals broad, upper half of filaments purplish blue, corolla purple in tone.*

TYPE 55. Medium in maturity, much branching both above and below, habit spreading and open ; average height 48 cm. *Foliage* dark green. *Flowers* medium in size, almost open ; petals broad, purple in tone ; filaments upper half purplish blue ; anthers pale blue ; stigmatic surfaces and tips white.

D. *Petals broad, upper half of filaments blue.*

TYPE 56. Very early, a good deal of branching below, mediumly open in habit ; average height 47 cm. *Foliage* bluish green. *Flowers* medium in size and mediumly open ; petals narrow ; filaments upper half blue, anthers pale blue ; styles blue, stigmatic surfaces and tips white.

4. Styles blue, stigmatic surfaces purple.

A. *Petals narrow, a very small amount of blue colour on the filaments below the anther.*

TYPE 57. Very late, a good deal of branching from the base, upper branches crowded and compact, very erect in habit ; average height 57 cm. *Foliage* dark green. *Flowers* medium in size, open, with a space between the petals which are narrow ; filaments with a small amount of pale blue just below the anther ; styles bright blue, stigmatic surfaces purple.

TYPE 58. Very late, a great deal of branching from the base, habit erect, mediumly compact ; average height 51 cm. *Foliage* dark green. *Flowers* small, do not open well ; petals narrow, with spaces in between ; filaments with a small amount of bright blue colour just below the anther ; styles blue, stigmatic surfaces purple.

TYPE 59. Medium in maturity, a small amount of basal branching, erect in habit ; average height 70 cm. *Foliage* light green. *Flowers* medium in size and mediumly open ; petals narrow ; filaments with a small amount of bright blue colour just below the anther ; styles blue, stigmatic surfaces purple, somewhat paler than in the rest of this class.

In Type 57 the colour on the filaments is pale blue, in Types 58 and 59 bright blue. These two types differ in the size of the flower and in the tone of colour of the stigmatic surfaces.

B. *Petals narrow, upper third of the filaments bright blue.*

TYPE 60. Late, erect, a great deal of branching both above and below, compact, crowded and erect in habit ; average height 55 cm.

Foliage somewhat light green. *Flowers* small, do not open well, somewhat deep blue in tone; petals narrow; filaments upper third bright blue; anthers bright blue; styles bright blue, stigmatic surfaces purple.

C. *Petals narrow, filaments with a small amount of purple just below the anthers.*

TYPE 61. Very early, erect, habit open; average height 51 cm. *Foliage* light green. *Flowers* small and mediumly open with a space between the petals which are narrow; filaments with a small amount of purple or very deep blue just below the anther; styles blue, stigmatic surfaces purple.

D. *Petals narrow, upper third of the filaments purple.*

TYPE 62. Late, a good deal of branching from the base, very erect, crowded and compact; average height 62 cm. *Foliage* dark green. *Flowers* medium in size, open; petals narrow with small spaces in between; filaments upper third purple or very deep blue; anthers pale blue; styles blue, stigmatic surfaces purple.

VAR. CAMPESTRE.

Seeds brown, medium in size. *Corolla* blue. *Stamens* anthers blue, filaments blue. *Styles* blue.

1. Styles pale blue, stigmas white sometimes tinged with pink.

A. *Corolla somewhat purple in tone.*

TYPE 63. Early, a small amount of branching below, a great deal above, habit erect, crowded and compact; average height 54 cm. *Foliage* dark green. *Flowers* medium in size, open; petals broad, purple in tone; filaments upper third purplish blue; styles pale blue, stigmatic surfaces white.

B. *Corolla normal blue.*

(*a*) *Early or very early, short, habit spreading.*

TYPE 64. Very early, somewhat open and spreading in habit, a little branching below, a great deal above; average height 49 cm. *Foliage* bluish green. *Flowers* medium in size, open; filaments upper fourth purplish blue; styles pale blue at the base, stigmatic surfaces white.

TYPE 65. Early, a small amount of branching below, a great deal above, habit spreading and open; average height 50 cm. *Foliage* bluish green. *Flowers* small, open; petals somewhat narrow with spaces in between; filaments upper third pale blue, most of the

colour on one side; styles pale blue at the base, white above stigmatic surfaces white with pink tips.

TYPE 66. Early, a very small amount of branching below, a great deal above, habit open; average height 48 cm. *Foliage* bluish green. *Flowers* medium in size, but larger than in Type 64, open; petals broad; filaments upper fourth blue; styles pale blue, stigmatic surfaces white.

These types differ in the size of their flowers and in the amount of colour on the filaments.

(*b*) *Medium in maturity, short, erect, with an open top.*

TYPE 67. Medium in maturity, a great deal of branching both above and below, habit erect with an open top; average height 48 cm. *Foliage* light green. *Flowers* medium in size, open, petals somewhat narrow with small spaces in between; filaments upper half pale blue; styles pale blue, stigmatic surfaces white with pink tips.

(*c*) *Late, tall, erect and compact in habit.*

TYPE 68. Late, a fair amount of branching below, very erect and compact in habit; average height 71 cm. *Foliage* somewhat light green. *Flowers* small, half closed; petals broad, blue in tone; filaments with a small amount of bright blue colour immediately below the anther; anthers bright blue; styles pale blue, stigmatic surfaces white.

TYPE 69. Late, some branching below, upright and compact in habit; average height 64 cm. *Foliage* dark green. *Flowers* medium to large, open; petals broad; filaments with a small amount of blue colour immediately below the anther; styles pale blue, stigmatic surfaces white.

These two types differ in the size of the flower and in height.

2. Styles blue (less pale than in 1), stigmatic surfaces pale purple.

A. *Petals narrow.*

TYPE 70. Medium in maturity, a good deal of branching both above and below, habit spreading with an open top; average height 49 cm. *Foliage* dark green. *Flowers* small, half closed; petals narrow with spaces in between; filaments upper third blue; anthers bright blue; styles blue, stigmatic surfaces white with pale purple tips.

TYPE 71. Medium in maturity, a great deal of branching both above and below, habit somewhat spreading and open; average height

45 cm. *Foliage* dark green. *Flowers* medium in size, open; petals somewhat deep blue in colour; narrow with spaces in between; filaments upper half blue; anthers pale blue; styles blue, stigmatic surfaces white with pale purple tips.

These two types differ in the size of their flowers and in the tone of colour of the anthers.

B. *Petals broad.*

Type 72. Late, a medium amount of branching below, habit spreading; average height 49 cm. *Foliage* dark green. *Flowers* large, open; petals broad with spaces in between; filaments upper third pale blue; styles blue, stigmatic surfaces white with pale purple tips.

Type 73. Late, much branching both below and above, habit somewhat spreading and open; average height 52 cm. *Foliage* somewhat light green. *Flowers* large, open; petals broad; filaments upper third bright blue; styles blue, stigmatic surfaces white with pale purple tips.

Type 74. Medium in maturity, much branching both below and above, habit spreading and open; average height 54 cm. *Foliage* bluish green. *Flowers* medium in size, mediumly open; petals broad; filaments upper third blue; styles blue, stigmatic surfaces white, tips pale purple.

Types 67 and 73 are late with large, open flowers. They differ in the tone of colour on the filaments. Type 74 is medium in maturity with medium sized flowers.

3. Styles blue, stigmatic surfaces purple.

A. *Petals narrow.*

Type 75. Medium in maturity, much branching both above and below, habit spreading with an open top; average height 53 cm. *Foliage* dark green. *Flowers* medium in size, open; petals narrow with spaces in between; filaments upper third pale blue; anthers pale blue; styles blue, stigmatic surfaces purple.

Type 76. Early, a small amount of branching below, a great deal above, habit erect, crowded and somewhat compact; average height 62 cm. *Foliage* bluish green. *Flowers* small, half open; petals very narrow with spaces in between, markings very prominent; filaments with a small amount of blue colour on one side immediately below the anther; styles blue, stigmatic surfaces and tips purple.

These two types differ in the size of the flowers and the amount of colour on the filaments.

B. *Petals intermediate in breadth.*

TYPE 77. Late, much branching both above and below, habit somewhat spreading and open; average height 54 cm. *Foliage* dark green. *Flowers* medium in size, almost open; petals somewhat narrow; filaments upper third purplish blue; anthers bright blue; styles blue, stigmatic surfaces and tips purple.

C. *Petals broad.*

TYPE 78. Medium in maturity, much branching both above and below, habit spreading and open; average height 50 cm. *Foliage* bluish green. *Flowers* medium in size, open; petals broad; filaments upper third pale blue; styles blue, stigmatic surfaces pale purple.

4. Styles bright blue, stigmatic surfaces bright purple, petals narrow.

TYPE 79. Early, much branching both below and above, habit somewhat spreading below, crowded above; average height 54 cm. *Foliage* dark green. *Flowers* small, mediumly open; petals narrow with wide spaces in between; filaments upper third bright blue; anthers bright blue; styles bright blue, stigmatic surfaces and tips bright purple.

5. Styles purplish blue, stigmatic surfaces pale purple, petals broad.

TYPE 80. Late, a little branching below, habit spreading and open; average height 60 cm. *Foliage* somewhat dark green. *Flowers* large, open; petals broad; filaments blue but the colour is mostly on one side; styles purplish blue, stigmatic surfaces pale purple.

var. VULGATUM.

Seeds brown, bold. *Corolla* blue. *Stamens* anthers blue, filaments blue. *Styles* blue.

1. Styles pale blue below, stigmatic surfaces white.

A. *Petals narrow.*

TYPE 81. Early, a small amount of branching below, a great deal above, habit erect but open; average height 45 cm. *Foliage* light green. *Flowers* small, mediumly open; the petals which are almost broad have no spaces in between, corolla light in tone; a trace of blue on the filaments; anthers faintly blue; styles very pale blue at the base, stigmatic surfaces white.

TYPE 82. Medium in maturity, a small amount of branching below, a great deal above, habit spreading and open ; average height 47 cm. *Foliage* dark green. *Flowers* small, open ; petals narrow, pale in tone ; filaments with a small amount of very pale blue colour immediately below the anther ; anthers very pale blue ; styles very pale blue, stigmatic surfaces white.

TYPE 83. Medium in maturity, much branching below, habit spreading and open ; average height 47 cm. *Foliage* light green. *Flowers* small, open ; petals somewhat narrow with small spaces in between ; filaments upper fourth blue ; styles pale blue at the base, stigmatic surfaces white.

TYPE 84. Early, a moderate amount of branching below, a great deal above, habit somewhat spreading ; average height 50 cm. *Foliage* somewhat light green. *Flowers* small, do not open fully ; petals somewhat narrow ; filaments upper third blue ; styles pale blue, stigmatic surfaces white.

There is only a trace of blue colour on the filaments in Types 81 and 82 which differ from one another in the time of maturity and in habit. In Type 83 the upper fourth of the filament is blue and the flowers are open, in Type 84 the upper third of the filament is blue and the flowers are half closed.

B. *Petals broad.*

TYPE 85. Very early, a very small amount of branching below, a great deal above, habit somewhat open ; average height 51 cm. *Foliage* bluish green. *Flowers* medium in size, open ; petals intermediate in breadth ; filaments with a small amount of blue colour immediately below the anther ; styles pale blue, stigmatic surfaces white.

TYPE 86. Early, habit somewhat open, a small amount of branching below, a good deal above ; average height 41 cm. *Foliage* light green. *Flowers* medium in size, half closed, corolla light in tone ; petals broad ; filaments upper half blue ; anthers pale blue ; styles pale blue at the base, stigmatic surfaces white.

TYPE 87. Early, a small amount of branching below, a great deal above, habit spreading and open ; average height 48 cm. *Foliage* dark green. *Flowers* medium in size, open ; petals broad ; filaments upper third deep blue ; anthers bright blue ; styles pale blue, stigmatic surfaces white.

TYPE 88. Medium in maturity, a small amount of branching below, a great deal above, habit spreading and open ; average height 52 cm.

Foliage dark green. *Flowers* large, open; petals broad ; filaments upper half deep purple ; anthers bright blue; styles pale blue below, stigmatic surfaces white.

These four types differ in the amount and tone of the colour on the filaments.

2. Styles completely blue, stigmatic surfaces white, sometimes tinged with pink or pale purple.

A. *Petals narrow.*

TYPE 89. Early, a small amount of branching below, a great deal above, habit spreading and open ; average height 56 cm. *Foliage* dark green. *Flowers* small, open ; petals very narrow with wide spaces in between, markings prominent owing to a white patch at the base of each petal ; filaments with a small amount of blue colour just below the anther on one side only ; styles blue ; stigmatic surfaces white tinged with pink.

TYPE 90. Medium in maturity, a moderate amount of branching, upright but open in habit ; average height 49 cm. *Foliage* light green. *Flowers* small, do not open well ; petals narrow with spaces in between ; filaments with a very small amount of bright blue colour immediately below the anther ; anthers pale blue ; styles blue, stigmatic surfaces white with a purple tinge.

TYPE 91. Early, a good deal of branching below, a great deal above, habit somewhat spreading and open ; average height 46 cm. *Foliage* light green. *Flowers* medium in size, open ; petals narrow ; filaments upper half purplish blue ; styles blue, stigmatic surfaces white tinged with pink.

TYPE 92. Early, a small amount of branching, spreading and open in habit ; average height 47 cm. *Foliage* bluish green. *Flowers* medium in size, open ; petals very narrow with much space in between, markings prominent owing to a white patch at the base ; filaments upper third blue ; styles blue, stigmas white tinged with pink.

TYPE 93. Medium in maturity, a very small amount of branching below, a great deal above, habit spreading and open ; average height 46 cm. *Foliage* dark green. *Flowers* small, open ; petals narrow with spaces in between, somewhat light in colour ; filaments upper third blue ; anthers a paler blue than in Type 92 ; styles blue, stigmas white tinged with pink.

These types differ from one another in the amount of colour on the filament. In both Types 89 and 90 this is very small, but in Type 89 it is found on one side only, whereas in Type 90 it occurs in the form of a ring. In Type 91 the upper third of the filament is purplish blue while in Types 92 and 93 the upper third is blue. These two types differ in maturity and in the tone of colour of the anthers.

B. *Petals broad.*

(*a*) *Upper third of the filaments blue.*

Type 94. Medium in maturity, a very small amount of branching below, a great deal above, habit spreading and open; average height 48 cm. *Foliage* bluish green. *Flowers* large, open; petals broad with spaces in between; filaments upper third blue; styles blue, stigmatic surfaces white, tips pink.

Type 95. Early, a small amount of branching at the base, habit spreading and open; average height 56 cm. *Foliage* dark green. *Flowers* large, open; petals broad; filaments upper third blue; styles blue, stigmatic surfaces white, tips pink.

Type 96. Medium in maturity, much branching at the top, a small amount below, habit crowded at top, somewhat spreading below; average height 54 cm. *Foliage* somewhat light green. *Flowers* large, open; petals broad; filaments upper third blue; styles blue, stigmatic surface white, tips pink.

In these three types the flowers are large and open. They differ in the time of maturity and in the colour of the foliage.

Type 97. Medium in maturity, very little branching at the base, a little but not much at the top, habit erect with an open top; average height 63 cm. *Foliage* dark green. *Flowers* medium in size, open; petals broad; filaments upper fourth blue; styles blue, stigmatic surfaces white, tips pink.

Type 98. Medium in maturity, a good deal of branching below, a great deal above, habit somewhat spreading with an open top; average height 53 cm. *Foliage* dark green. *Flowers* medium in size, open; petals broad; filaments upper third blue; styles blue, stigmatic surfaces white, tips pink or pale purple.

Type 99. Early, a small amount of branching below, a great deal above, habit erect with an open top; average height 60 cm. *Foliage* light green. *Flowers* medium in size, mediumly open; petals broad; filaments upper third blue; styles pale blue, stigmatic surfaces white, tips pink or pale purple.

TYPE 100. Medium in maturity, a small amount of branching below and a good deal above, habit spreading and open ; average height 49 cm. *Foliage* somewhat light green. *Flowers* medium in size, open ; petals broad ; filaments upper third blue ; styles light blue, stigmatic surfaces white tinged with purple.

In these four types the flowers are medium in size. They differ in height and in the time of maturity.

TYPE 101. Early, a fair amount of branching below, much branching at the top, habit somewhat open ; average height 56 cm. *Foliage* light green. *Flowers* small, half open ; petals broad ; filaments upper third blue ; styles blue, stigmatic surfaces white with pink tips.

In this type the flowers are small.

(*b*) *Filaments upper third purple, corolla very deep blue.*

TYPE 102. Very early, a small amount of branching from the base, erect and somewhat open in habit ; average height 56 cm. *Foliage* light green. *Flowers* medium in size, mediumly open ; petals broad, very deep blue ; filaments upper third deep purple ; anthers bright blue ; styles pale violet, stigmatic surfaces white, tips pink.

TYPE 103. Medium in maturity, a little branching at the base, a great deal above, habit spreading with an open top, average height 56 cm. *Foliage* dark green. *Flowers* large, open ; petals somewhat deep blue, broad ; filaments upper third purple ; anthers very pale blue ; styles bluish violet, stigmas white tinged with pink.

These two types differ in the time of maturity, in habit and in the size of their flowers.

3. Styles blue, stigmatic surfaces purple.

A. *Filaments with a small amount of colour generally on one side only.*

TYPE 104. Early, a small amount of branching below, a great deal above, habit upright but open ; average height 55 cm. *Foliage* dark green. *Flowers* small, half closed ; petals narrow with large spaces in between, the petals being folded in the centre ; filaments with a small amount of blue colour immediately below the anther ; styles blue, stigmatic surfaces and tips purple.

TYPE 105. Late, a small amount of branching below, a great deal above, habit spreading and open ; average height 54 cm. *Foliage* dark green. *Flowers* large, open ; petals very narrow, markings

prominent owing to the white base ; filaments upper fourth purplish blue immediately below the anther ; styles blue, stigmatic surfaces pale purple.

TYPE 106. Early, much branching below and above, habit spreading and open ; average height 41 cm. *Foliage* dark green. *Flowers* small, open ; some space between the petals which are almost broad ; filaments with a small amount of blue colour immediately below the anther ; anthers very pale blue ; styles blue, stigmatic surfaces purple.

TYPE 107. Late, a small amount of branching below, a great deal above, habit spreading and open ; average height 50 cm. *Foliage* dark green. *Flowers* medium in size, open ; petals narrow with large spaces in between ; filaments with a small amount of blue colour immediately below the anther ; anthers pale blue ; styles blue, stigmatic surfaces purple.

These four types differ in the time of maturity and in the size of their flowers.

B. *Upper third of the filaments blue, the colour in the form of a ring.*

TYPE 108. Very early, very little branching either at the base or above, habit erect with an open top ; average height 57 cm. *Foliage* bluish green. *Flowers* small, half open ; petals somewhat narrow but still belonging to the broad class ; filaments upper half purple ; anthers blue ; styles blue, stigmatic surfaces purple.

TYPE 109. Early, a medium amount of branching, habit open and spreading ; average height 47 cm. *Foliage* somewhat light green. *Flowers* small, mediumly open ; petals narrow with spaces in between ; filaments upper third blue ; styles blue, stigmatic surfaces pale purple.

TYPE 110. Medium in maturity, a small amount of branching below, a great deal above, habit spreading and open ; average height 41 cm. *Foliage* dark green. *Flowers* small, open, with spaces between the petals which are narrow ; filaments upper third purplish blue ; anthers pale blue ; styles blue, stigmas purple.

TYPE 111. Medium in maturity, a good deal of branching, habit crowded but open ; average height 45 cm. *Foliage* dark green. *Flowers* small to medium in size and mediumly open ; petals narrow ; filaments upper third blue ; anthers pale blue ; styles blue, stigmatic surfaces bright purple.

In these four types the flowers are small and not very open with narrow petals. They differ in the time of maturity and in height.

TYPE 112. Very early, branching sparse, habit open; average height 45 cm. *Foliage* dark green. *Flowers* medium in size, open; petals narrow with spaces in between; filaments upper third blue; styles blue, stigmatic surfaces bright purple.

TYPE 113. Early, habit erect and crowded, a small amount of branching below, a great deal above; average height 55 cm. *Foliage* light green. *Flowers* medium in size, almost open; petals broad, pale blue; filaments upper third purplish blue; styles blue, stigmatic surfaces purple.

TYPE 114. Medium in maturity, a small amount of branching below, a great deal above, habit spreading and open; average height 52 cm. *Foliage* dark green. *Flowers* medium in size, open; petals narrow with large spaces in between, markings very prominent owing to the white base of the petal; filaments upper third blue; styles blue, stigmatic surfaces bright purple.

TYPE 115. Medium in maturity, a small amount of branching below, a great deal above, habit erect but open; average height 49 cm. *Foliage* light green. *Flowers* medium in size, open, some space between the petals which are narrow; filaments upper third purplish blue; styles blue, stigmas purple.

TYPE 116. Late, a good deal of branching, habit crowded but somewhat open; average height 50 cm. *Foliage* somewhat light green. *Flowers* medium in size, almost open; petals narrow with spaces in between; filaments upper third blue; anthers very pale blue; styles blue, stigmatic surfaces bright purple.

4. Styles purple, stigmatic surfaces white with purple tips.

TYPE 117. Early, a small amount of branching below, a great deal above, habit spreading and open; average height 45 cm. *Foliage* light green. *Flowers* medium in size, open; petals narrow with spaces in between; filaments upper half purple; styles purple, stigmatic surfaces white, tips purple.

VAR. TINCTORIUM.

Seeds brown, bold. *Corolla* purple. *Stamens* anthers blue, filaments blue. *Styles* blue.

TYPE 118. Very early, a fair amount of branching both below and above, habit somewhat spreading and open; average height 44 cm.

Foliage dark green. *Flowers* small, do not open fully; petals very narrow, edges incurved, colour bluish purple; filaments upper third purplish blue; anthers pale blue; styles pale blue below, violet above, stigmatic surfaces white tinged with pink.

Type 119. Very early, a fair amount of branching both below and above, habit somewhat spreading and open; average height 49 cm. *Foliage* light green. *Flowers* small, do not open fully; petals broad, almost pink, markings dark blue and very prominent; filaments upper third pale blue; styles pale blue at the base, stigmas white.

Type 120. Medium in maturity, a fair amount of branching both below and above, habit somewhat spreading and open; average height 50 cm. *Foliage* somewhat dark green. *Flowers* medium in size, do not open well, colour a bluish purple; petals broad; filaments upper third purple; anthers pale blue; styles pale blue at the base, stigmas white.

In Type 118 the petals are narrow whereas they are broad in Types 119 and 120. These two types are easily distinguished by the colour of their corolla.

var. SATIVUM.

Seeds brown, small. *Corolla* violet. *Stamens* anthers blue, filaments blue. *Styles* blue.

Type 121. Medium in maturity, much branching both above and below, habit erect, crowded and compact; average height 52 cm. *Foliage* dark green. *Flowers* large, open, resemble the normal blue in depth of colour except that they are violet not blue; petals broad; filaments upper third purplish blue; anthers very pale blue; styles pale blue, stigmatic surfaces white.

Type 122. Early to medium in maturity, a small amount of branching below, a great deal above, habit spreading and open; average height 57 cm. *Foliage* light green. *Flowers* large, open, colour pinker in tone than in Types 121 and 123; petals broad; filaments pale violet; anthers bright blue; styles pale violet blue with deep blue lines on the sides, stigmatic surfaces pale violet.

Type 123. Early, a small amount of branching below, a great deal above, habit spreading and open; average height 50 cm. *Foliage* bluish green. *Flowers* medium in size and mediumly open; petals narrow with small spaces in between, resembling Type 121 in colour but slightly darker; filaments upper third purple on one

side only; anthers very pale blue; styles pale blue, stigmatic surfaces white.

Type 123 can be distinguished from the other two by the narrowness of its petals. Type 121 differs from Type 122 in the tone of colour of the filaments, anthers and styles.

V. THE ECONOMIC ASPECT.

The commercial classification of Indian linseed is based on the size and colour of the seed. Three sizes are recognized—bold, medium and small—and two colours are distinguished—yellow and brown. Other things being equal, the larger seeds fetch a higher price. As would be expected, these differences in price depend largely on oil content. This is clear from the percentages of oil (ether extract) in the various types (Table VIII). The determinations were made from samples grown at Pusa in 1919 where the soil conditions favoured the small brown types.

TABLE VIII.

Oil content and size of seed.[1]

Type No.	Size and colour of seed	Percentage of oil (ether extract)
1 2 3	Bold yellow	41·85 42·69 41·93 } mean 42·15
6 7 80	Bold fawn	43·95 43·31 44·76 } „ 44·01
84 103	Bold brown	42·32 44·36 } „ 43·81
68 72	Medium brown	38·91 39·38 } „ 39·15
12 19 20 28 29 32 121	Small brown	36·18 37·20 40·07 35·12 37·80 37·19 39·00 } „ 37·51

It will be evident from the above table that there is a certain amount of correlation between the size of the seed and the oil content. This is probably due to the greater percentage of husk in the smaller seeded varieties. There

[1] Previous determinations of the oil content have been carried out on mixed samples and are, therefore, not very significant.

are also differences between the individual types in any one group but these are insignificant compared with that between the bold and small seeded varieties. To obtain a high oil content, the cultivation of a large seeded type would appear essential.

As regards the colour, it is sometimes stated that the pale seeded varieties are the most valuable.[1] It is possible that this belief has partly arisen from the fact that all the yellow varieties have bold seeds and are therefore rich in oil content. The following letter from Messrs. Ralli Brothers, dated Bombay, 17th March, 1919, makes the position clear as regards the relative value of the brown and yellow colour for the export trade.

" With reference to the conversation we have had some time ago, on the above subject, we are informed by our Home Firms that crushers in the south of France pay particular attention to edible oils, and as a mixture of yellow seeds up to 25 per cent. in brown linseed gives a finer quality of oil and moreover a higher proportion of edible oil, buyers show a marked preference for such qualities.

The same, however, is not the case with buyers of the north of France and in the United Kingdom where they like better brown seeds, with no admixture of yellow seeds, the latter rendering the sale of the cake difficult, by discolouring it. A high admixture of yellow seeds, would also be objected to in Marseilles, for the same reason."

The economic value of any variety of linseed depends, however, not only on the percentage of oil in the seed but also on the yield of seed obtained per acre and of the two this latter factor is the more important. High yields of seed are only obtained if the variety is suited to the soil and climatic conditions of the locality. It is generally found that this depends almost entirely on the suitability of the root system to its environment. The only other morphological character which appears to be important from the economic point of view is the power of branching. As has been seen on page 142, the number of basal branches varies very much with the soil conditions, but, in addition to this, the power of forming numerous branches is a distinct inherited varietal character. This is true both of the primary branching from the base and the secondary branching above. In 1921, when grown under exactly comparable conditions, the average number of branches per plant varied from two to fourteen among the 121 types. In choosing a variety for distribution, it is essential to choose one of which the potential branching power is large.

[1] Duthie, J. F. and Fuller, J. B. in *Field and Garden Crops of the North Western Provinces and Oudh*, 1883, Part II, p. 41, state that oil of the " white seeded " variety is in many respects more valuable than that of the ordinary linseed especially for colour mixing.

Another character which is important from the point of view of seed distribution, although it does not directly affect the yield, is the colour of the corolla. In most districts, the local linseed is blue flowered. It is extremely difficult to distinguish one blue flowered variety from another. The F_1 between two blue corollas is usually blue also. Thus if the improved variety has a blue corolla it is practically impossible to check the extent of the distribution and the purity of the crops. A white, purple or lilac coloured corolla is, therefore, a distinct asset in an improved variety.

As regards the introduction of improved varieties, it has been found that all the types with *bold* seed (*i.e.*, a high percentage of oil) belong to Peninsular India and will not thrive on the alluvium, except possibly in the Punjab. As was mentioned on page 138, this is due to the fact that all these types so far obtained have a deep root system. Seed of the bold seeded types isolated during this investigation has, therefore, been sent to the Department of Agriculture of the Central Provinces for trial. Some of them were said in 1922 to be distinctly promising and further trials will probably indicate more definitely which of these types are suitable for distribution. It is also hoped to carry out trials of these bold seeded types in other localities of the black cotton soil area.

As regards the alluvium, variety trials have been carried out during the last three years at Pusa with some of the more promising types. Three types (12, 29 and 121) have consistently emerged as definitely superior to the local variety. Of these improved kinds, Type 29 is blue flowered, Type 121 purple flowered and Type 12 white flowered. In 1923, Types 121 and 12 in a series of very careful tests gave a yield 40 to 50 per cent. above that of the local variety. The actual yields per acre on the most reliable series of plots was :—

Type 121	.. .. ..	11½ maunds per acre.
Type 12	.. .. ..	11½ maunds per acre.
Local	.. .. ..	7½ maunds per acre.

These yields are so very promising that seed of both Types 12 and 121 have been distributed for trial to the Provincial Departments of Agriculture and others. Type 29, though giving yields as high as Types 121 and 12, suffers in Bihar from the disadvantage of secondary flowering. It is therefore only suitable for localities with a longer growth period than Bihar and has been sent to the Punjab for trial. Further tests with other types are in progress at Pusa, but the success of the preliminary trials leaves no doubt that the yield of linseed on the alluvium can be very considerably increased by the systematic distribution of these improved kinds.

Experiments are also in progress to see whether it is possible to produce by hybridization a bold seeded variety suitable for the United Provinces and Bihar which will give a high yield of seed. It will be interesting to see whether such a combination is possible. The fact that none of the bold seeded types, isolated by selection, are at all suitable is against it, as is also the observation that the large seeded varieties of almost all crops—*khesari* (*Lathyrus sativus*), lentils (*Ervum lens*), etc., generally belong to the black cotton soil areas whereas, in Bihar, the corresponding varieties have very small seeds. There is, however, one striking exception to this rule. Although the local varieties of wheat are particularly small grained, it has been possible to obtain a very large seeded wheat, Pusa 4, which is well suited to certain tracts of the alluvium and gives a high yield. As, however, such a variety of linseed will have to be created by hybridization, it will take several years before the desired result can be achieved.

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